Numerical Modeling of Conjugate Heat Transfer in Fluid Network

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ABSTRACT

Fluid network modeling with conjugate heat transfer has many applications in Aerospace engineering. In modeling unsteady flow with heat transfer, it is important to know the variation of wall temperature in time and space to calculate heat transfer between solid to fluid. Since wall temperature is a function of flow, a coupled analysis of temperature of solid and fluid is necessary. In cryogenic applications, modeling of conjugate heat transfer is of great importance to correctly predict boil-off rate in propellant tanks and chill down of transfer lines.

In TFAWS 2003, the present author delivered a paper to describe a general-purpose computer program, GFSSP (Generalized Fluid System Simulation Program). GFSSP calculates flow distribution in complex flow circuit for compressible/incompressible, with or without heat transfer or phase change in all real fluids or mixtures. The flow circuit constitutes of fluid nodes and branches. The mass, energy and specie conservation equations are solved at the nodes where as momentum conservation equations are solved at the branches.

The proposed paper describes the extension of GFSSP to model conjugate heat transfer. The network also includes solid nodes and conductors in addition to fluid nodes and branches. The energy conservation equations for solid nodes solves to determine the temperatures of the solid nodes simultaneously with all conservation equations governing fluid flow. The numerical scheme accounts for conduction, convection and radiation heat transfer.

The paper will also describe the applications of the code to predict chill down of cryogenic transfer line and boil-off rate of cryogenic propellant storage tank.